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ABSTRACT

This paper describes one preservice secondary teacher's beliefs about mathematics and discusses how these beliefs were related to her teaching practice. The participant was interviewed and observed throughout the final academic year of her undergraduate preservice program (methods course and student teaching). Although she communicated beliefs emphasizing the importance of cooperative exploration by students to understand connections among mathematical concepts, some of her more narrow views about the importance of mathematical procedures inhibited her ability to successfully implement exploratory, student-centered learning activities during her student teaching. Contains 12 references. (Author/DDR)

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# The Impact of a Secondary Preservice Teacher's Beliefs about Mathematics on her Teaching Practice

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# THE IMPACT OF A SECONDARY PRESERVICE TEACHER'S BELIEFS ABOUT MATHEMATICS ON HER TEACHING PRACTICE

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This paper describes one preservice secondary teacher's beliefs about mathematics and discusses how these beliefs were related to her teaching practice. The participant was interviewed and observed throughout the final academic year of her undergraduate preservice program (methods course and student teaching). Although she communicated beliefs emphasizing the importance of cooperative exploration by students to understand connections among mathematical concepts, some of her more narrow views about the importance of mathematical procedures inhibited her ability to successfully implement exploratory, student-centered learning activities during her student teaching.

In our effort to describe how preservice secondary teachers' beliefs about the nature of mathematics are related to their teaching, we build upon ideas discussed previously (Benken & Wilson, 1996) and report the results of a second case. Attempting to better understand preservice teachers' beliefs about the nature of mathematics has become an important area of study for mathematics teacher education (Cooney, 1994; Thompson, 1992). Teachers' understanding of the nature of mathematics strongly influences their views of mathematics teaching and can play a significant role in shaping teachers' patterns of instructional behavior (Ernest, 1989, 1991; Lerman, 1990; Thompson, 1992; Lloyd & Wilson, 1998).

The relationship between teachers' beliefs and teaching practices is extremely complicated. Although existing research suggests that these factors are interdependent (Wood, Cobb & Yackel, 1991), more research is necessary to better understand the nature of their interactions (Thompson, 1992). Often, there is a disparity between espoused beliefs and what a teacher actually does in the classroom (Ernest, 1989, 1991; Thompson, 1992). More research that examines preservice teachers' beliefs beyond the methods course into their practice during student teaching would be helpful to better understand this relationship (Pajares, 1993).

To aid in our interpretations, we used three categories described by Ernest (1989) to characterize individual's views of the nature of mathematics: *Problem-Solving, Platonist and Instrumentalist*. Ernest (1989, 1991) and Lerman (1990) have theorized that a teacher's philosophy of mathematics forms a basis for her mental models of the teaching and learning of mathematics. Other research corroborates this claim (Smith, 1996; Thompson, 1992).

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According to the Problem-Solving view, mathematics is seen as a continually growing field of human creation that develops through conjectures, the generation of patterns, proofs and questioning. The results of mathematics remain open to revision. Teachers with Problem-Solving views are likely to think of themselves as facilitators who allow students opportunities to explore, generate and solve problems, and construct their own understandings. Problem-Solving teachers approach teaching in ways that stimulate classroom discourse, encourage student investigation and cooperative learning, and create an environment necessary for students to make connections within mathematics and to the world around them.

The Platonist view suggests that mathematics is "a static but unified body of certain knowledge," which is discovered and not created (Ernest, 1989, p. 250). This view involves a global understanding of mathematics as a "consistent, connected and objective structure." A teacher with Platonist views of mathematics is likely to see her primary role as explainer, and as one who should guide students to the solution or her intended goal. In general, a Platonist teacher emphasizes conceptual understanding with unified knowledge, and sees the students as "receptors of knowledge" (Ernest, 1989, p. 251).

The Instrumentalist maintains that mathematics is a fixed set of rules, facts and procedures for computing numerical and symbolic expressions to find answers. The Instrumentalist view is likely to be associated with a "telling" model of teaching, where teachers emphasize mastery of skills, rules, and procedures and usually strictly follow a text or scheme. A teacher's central role is to provide clear, step-by-step demonstrations of procedures, respond to students' questions, and provide opportunity for students to practice procedures (Smith, 1996). Solving problems is "a matter of recalling and applying the procedure appropriate for the given problem type" (Smith, 1996, p. 391).

## DESIGN

An ethnographic case study design was employed (Stake, 1995). Data were collected between September 1995 and June 1996. Twenty-four secondary mathematics methods students responded to a written survey at the beginning of the course, and we selected 2 preservice teachers for more

in-depth study. This paper reports the experiences of one of these teachers (Leslie). Four semi-structured audio-taped interviews (approximately one hour in length), conducted during the methods course and student teaching, allowed Leslie to elaborate survey responses and communicate her views about mathematics, the methods course, and practice teaching experiences. Her bi-weekly tutoring experiences (part of the methods course) were observed. Photocopies of selected written assignments completed in the methods course were also analyzed. During student teaching, informal interviews (length varied from 20 minutes to one hour) followed seven observations. Finally, Leslie was observed during 12 student teaching seminars. Fieldnotes of observations and informal interviews were taken and later analyzed.

## RESULTS

At the beginning of the methods course, Leslie communicated that mathematics was sequentially ordered, and that doing mathematics involved applying steps in order and mastering types of problems. For example, on the initial survey, she chose *cooking with a recipe*, from a list of eight similes, as the one that best describes what learning mathematics is like. In elaborating this response, she explained, "When I cook, I sometimes don't always have the exact tools and ingredients, so I improvise. However, I still do the basic steps in order, building from the bottom-up." Leslie's explanation suggests that she believed mathematics to be ordered, with each component building from the previous. To her, doing mathematics involved applying steps in a specific order. Such an emphasis on steps is most consistent with an Instrumentalist view of mathematics.

However, in some cases she articulated views that were more consistent with a Platonist view of mathematics. For example, Leslie saw mathematics as a connected, and somewhat creative, reasoning process. During our first interview, Leslie's elaboration of her survey response about cooking suggests she understood and valued connections within mathematics. She said,

> There's obviously some steps that you can't skip, or just kind of breeze through or you'll miss a lot. Like when you take the first course where you have to do a lot of proofs, if you don't really learn how to do the proofs, then you'll really have difficulty later on. Or, if

> you're doing trigonometry, and you don't get the relationships down between cosine and sine, then you'll have difficulty later on.

Leslie saw the steps (or various parts) of mathematics as being connected and important for the understanding of future topics. In her view, the ordering within mathematics was necessary for the understanding of and relationships among important mathematical ideas.

During the methods course, Leslie continued to struggle with her fundamental beliefs. She focused on the connectedness and understanding of mathematical ideas, the importance of and creativity involved in problem solving, and the value of applications. During the second month of the methods course, on an electronic shared assignment that required participants to comment on the changes recommended in the *Standards* (NCTM, 1989), Leslie articulated her view of doing mathematics as a logical thought process. She wrote:

> For me, it wasn't learning the rules of mathematics that made everything make sense now in calculus, differential equations, analysis, etc. It was, pardon the colloquialism, 'training my brain' to process the information and transform it, and above all, being able to logically reason that a given solution makes sense.

Although Leslie alluded to the rules of mathematics, she emphasized that a useful and important part of the foundation of mathematics is the ability to reason through and think about problems and connections between problems and solutions.

During student teaching, Leslie's comments confirmed that she viewed mathematics as a connected discipline. In many of her lessons, she stressed connections, both within mathematics and to the real world. She frequently claimed during discussions that she wanted to help her students understand these connections and see the usefulness of mathematics. For example, on one occasion, Leslie passionately commented:

> Getting them to take things to higher level and not think about them on a really basic level was difficult. They still want an easy answer, they want a formula, they want to know what numbers to push on the calculator. I'm more concerned about getting them to understand what it means.

Here Leslie stresses that meaning is more important than formulas or answers. Leslie followed the above comment with an example using rational numbers. Although the properties themselves were important to learn, she said that she considered the understanding that would be gained by trying to explore and derive them to be even more important. These statements, along with others made at the end of the year, suggest that during Leslie's student teaching, her views expanded to include an even more connected, conceptual and useful view of mathematics.

During her student teaching, several patterns emerged in Leslie's practice that suggest she struggled with how to balance these desires and growing recognition of connections with her more Instrumentalist views of mathematics. For example, her teaching suggested she wanted to be certain that her students first understood the basics, or foundation, before she felt comfortable letting them explore and investigate. To Leslie, if she did not make certain that her students understood the basics, then they would have difficulty understanding future mathematical concepts, which are built upon the foundation. During a lesson she led on February 21, 1996, Leslie chose to review only components of a student project that she considered to be fundamental to the activity. In this review she chose not to discuss students' observations and written reflections of their findings.

During our final interview in April, Leslie reflected on several of her lessons that involved group activities and made the following comment:

> They seem to enjoy doing them because they like to work together and they like to do something different, but I'm not always sure how well it helped them to learn what they are doing....[For example] in that general math class we were talking about area and I had them measuring the area of certain surfaces in the room....and they were having trouble with area being a two-dimensional measurement.

As this example illustrates, Leslie tried to develop activities that would help her students to understand the concepts she valued through cooperative learning and exploration. Although she did not want to fall into the book-lecture format, and would often search for other ways to "get at the same material without just telling," she reflected that often she made sure she went over certain

material, in addition to allowing the students time to work together. Leslie struggled to balance student exploration with teacher dissemination of basic, fundamental concepts because she valued both.

On April 29, 1997, Leslie taught a lesson on subtracting integers. She used an interactive lecture format to demonstrate multiple ways to approach the concept. At the beginning of the lesson, before discussing examples that used number lines and manipulatives, Leslie told her class about rules for subtracting integers. She stated, "There are basically three ways to think about subtraction of integers. The first is 'SMATO,' or subtraction means adding the opposite." A student then asked if she could always "do that." Leslie replied, "If subtracting, yes. It always works." During our discussion before this lesson, Leslie indicated that she would be presenting three different ways of looking at subtraction. During her lesson she chose to show them the rule, or "straight forward algebra," way of looking at subtraction first, without added explanation or interpretation, then she introduced examples. This instructional pattern of introducing rules followed by examples, which Leslie repeated throughout the semester, illustrates how her view of mathematics as a connected set of fundamental procedures, played itself out during her student teaching.

## DISCUSSION

Can teachers implement practices consistent with reform while maintaining some core Instrumentalist views? Although Leslie communicated beliefs about mathematics during the methods course and student teaching that can be categorized as Platonist (e.g., emphasis on connections), her more Instrumentalist views appeared to inhibit her ability to fully implement some of her innovative ideas. From the beginning of the study, Leslie's belief that mathematics is learned sequentially and built upon a foundation, influenced her decision to make certain that she provided her students with what she perceived to be the basics before allowing them to explore and investigate problems. Leslie claimed that using cooperative group activities was a good way for students to learn concepts and generate algorithms, and she even occasionally attempted to

implement them. However, when her students reacted negatively to the activities, she became frustrated and questioned the validity of cooperative, student-centered learning approaches.

Leslie's teaching practices were no doubt influenced by her own experiences as a mathematics learner and the traditional teaching practices of her cooperating teacher, who served as her mentor and model. Nevertheless, we believe that Leslie's main obstacle to implementing the teaching practices she envisioned were her own conceptions of mathematics and mathematics teaching. We are confident, however, that Leslie's conceptions of mathematics, teaching, and student learning will continue to develop, enabling her to implement the strategies she desires so her students can attain the understandings she values. Like many teachers who attempt to implement reform ideas, Leslie seems to have "one foot in each of two conflicting paradigms" (Goldsmith & Schifter, 1997, p. 28). Leslie's experiences can help teacher educators and others interested in implementing teaching ideas consistent with reform recommendations understand why the process of change is so difficult for teachers.

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